Egyptian Journal of Chest Diseases and Tuberculosis (2013) **62**, 59–63

The Egyptian Society of Chest Diseases and Tuberculosis

Egyptian Journal of Chest Diseases and Tuberculosis

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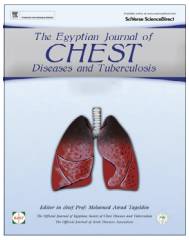

ORIGINAL ARTICLE

Factors predicting exercise-induced oxygen desaturation in stable COPD

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Received 20 November 2012; accepted 18 February 2013
Available online 18 March 2013

KEYWORDS

COPD;
Exercise;
Desaturation;
Base-line SaO_2

Abstract *Background:* Exercise induced oxygen desaturation (EID) is highly prevalent among patients with COPD. We suggested that, some resting pulmonary functions and blood gas parameters might be used as screening test to predict exercise-induced oxygen desaturation in COPD.

Objective: The aim of this work was to evaluate different parameters that might predict (EID) in COPD patients.

Design: Randomized, double blind, prospective study.

Methods: This study included 55 patients with stable COPD, resting pulmonary functions; arterial blood gases, echocardiography, and incremental cardiopulmonary exercise testing were done for all patients. We considered the patient to be desaturated if O_2 saturation decreased $\geqslant 4$ mmHg with exercise. We compared desaturated (DS) and nondesaturated (NDS) patients.

Results: Oxygen desaturation was found in 28 subjects after CPET, while 27 subjects were nondesaturated (NDS). $FEV_1\%$ was significantly lower in DS ($P = 0.001$), DLCO was significantly lower in DS ($P = 0.001$), and resting oxygen saturation (base-line) was significantly lower in DS ($P = 0.000$). Resting $PaCO_2$ was significantly higher in DS ($P = 0.000$), pulmonary artery systolic pressure PAP was significantly higher in DS ($P = 0.016$), and mMRC score was significantly higher in DS ($P = 0.000$), while there were no statistically significant differences of age, FEV_1/FVC, (TLC), and (RV).

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Peer review under responsibility of The Egyptian Society of Chest Diseases and Tuberculosis.

ELSEVIER Production and hosting by Elsevier

 http://dx.doi.org/10.1016/j.ejcdt.2013.02.009

On performing regression analysis the most sensitive predictor for EID was base line SaO_2 (resting SaO_2).

Conclusion: Although multiple factors can predict EID in stable COPD (FEV_1%, DLCO, resting SaO_2, $PaCO_2$, mMRC score, and PAP), base line SaO_2 is the most sensitive factor.

Introduction

The most common functional impairment in patients with all types of lung diseases is impaired gas exchange. In the early stages of many lung diseases, oxygen saturation is maintained at rest, but when the lung is challenged with increasing demand (exercise), oxygen desaturation may occur [1]. Many previous investigators have studied the predictors of oxygen desaturation during maximal exercise in patients with COPD [1].

Exercise induced oxygen desaturation (EID) is highly prevalent among patients with COPD. EID seems to be associated with impaired daily physical activity which supports its clinical importance [2]. Earlier studies have suggested early mortality in patients with COPD who are normoxic at rest but experience exercise desaturation [3,4].

Oxygen supplementation with exertion can increase peak exercise level, decrease minute ventilation, improve exercise tolerance, decrease dyspnea, and prevent transitory increases in pulmonary arterial pressure and pulmonary vascular resistance at sub-maximal workloads [5,6].

Previous studies have determined that baseline forced expiratory volume in 1 s (FEV_1) or diffusing capacity for carbon monoxide (DLCO) can serve as screening tests to predict which COPD patients will desaturate with exercise [7,8].

Objective

The aim of this work is to study different parameters that may predict EID in COPD patients, as regards pulmonary function tests and haemogasometric parameters.

Patients and methods

The present study was conducted in the Department of Chest Diseases, Faculty of Medicine, Assiut University Hospital from March, 2008 to January, 2011. The study included 55 patients with chronic obstructive pulmonary diseases (COPD), diagnosis of COPD was done according to Global Initiative for chronic obstructive lung disease guideline, 2008.

All patients were subjected to full medical history, where dyspnea was graded according to modified Medical Research Council (mMRC), general and local chest examination, Chest X-ray PA view, spirometry, and incremental CPET using (Cosmed SrL, Quark PFTs ergo, P/N Co9035-12-99, made in Italy). Lung volumes and diffusion capacity of the lung for carbon monoxide were determined using single breath method (D 97723; Zan 300, Oberthulba, Germany).

Arterial blood gases in room air were obtained both at rest and at the end of exercise by blood sample from radial artery and analyzed using blood gases analyzer (Rapid lab 850; CHIRON/Diagnostics; critical care systems). Two dimensional Doppler echocardiography was done on all patients.

Exclusion criteria

(1) Patients with primary cardiac diseases include ischemic heart diseases, cardiomyopathy, unstable angina, valvular heart diseases, and myocardial infarction.
(2) Respiratory failure.
(3) Decompensated cor-pulmonale.
(4) Acute pulmonary embolism.
(5) Uncontrolled cardiac arrhythmia.
(6) Severe arterial hypertension.

We considered that a patient would develop exercise-induced oxygen desaturation if O_2 saturation decreased $\geqslant 4\%$ with exercise. We compared desaturated (DS) with non-desaturated (NDS) patients.

Results

By comparing clinical and functional parameters between desaturated (DS) and non-desaturated (NDS) COPD patients, we observed that there was no significant difference between both as regards age, FEV_1/FVC, TLC, and RV (residual volume), but FEV_1 and DLCO were significantly lower in the DS group, while mMRC dyspnea score was significantly lower in NDS patients (Table 1).

Table 1 Clinical and functional parameters.

Parameters	Desaturated	Nondesaturated	*P* value
	Mean ± SD (28)	Mean ± SD (27)	
Age	55.86 ± 9.35	58.00 ± 8.788	0.386
FEV_1/FVC	53.87 ± 10.12	54.77 ± 9.89	0.358
FEV_1 (%)	33.75 ± 9.28	49.49 ± 19.86	0.001*
TLC (%)	107.25 ± 33.237	116.52 ± 29.494	0.280
RV	201.46 ± 74.524	202.11 ± 63.634	0.973
DLCO	47.54 ± 20.25	67.35 ± 19.62	0.001*
mMRC score	3.54 ± 0.69	2.44 ± 0.97	0.000*

* means significant < 0.05.

Table 2 Haemogasometric parameters.

Parameters	Desaturated	Nondesaturated	*P* value
	Mean ± SD (28)	Mean ± SD (27)	
Base-line SaO_2	91.92 ± 2.88	95.94 ± 2.9	0.000*
Resting $PaCO_2$	63.46 ± 11.58	38.97 ± 6.38	0.000*
PAP	42.21 ± 11.90	34.15 ± 12.14	0.016*

* means significant < 0.05.

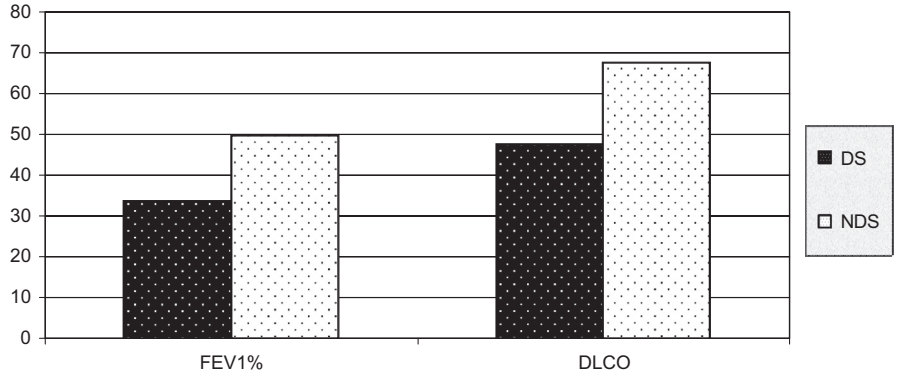

Figure 1 Comparison between FEV_1 & DLCO in both groups.

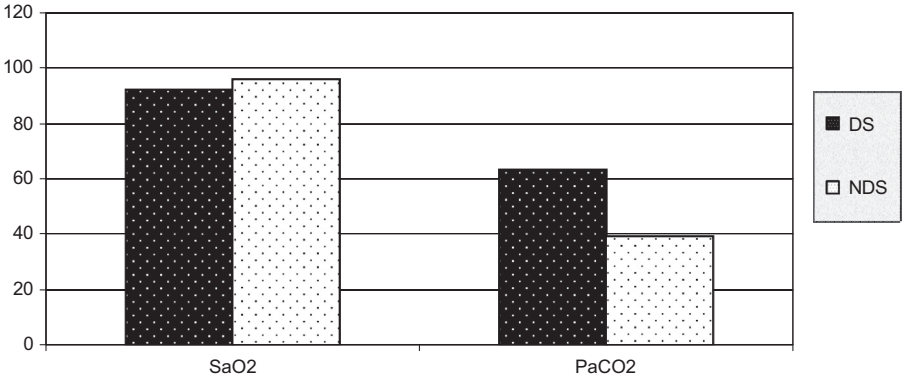

Figure 2 Comparison between resting SaO_2 & $PaCO_2$ in both groups.

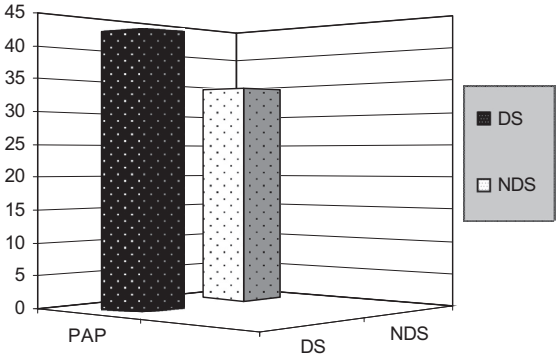

Figure 3 Comparison between pulmonary artery systolic pressure (PAP) in both groups.

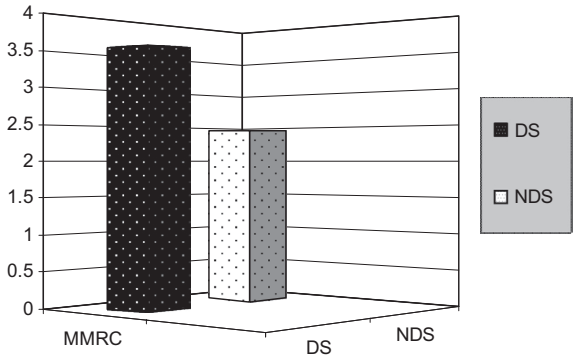

Figure 4 Comparison between mMRC dyspnea scales in both groups.

Table 2 in which comparing haemogasometric parameters in both groups demonstrated that PAP (pulmonary artery systolic pressure) and $PaCO_2$ were significantly higher in DS patients, while base-line SaO_2 was significantly lower in the same group of patients.

Figs. 1–4 are graphic presentations of differences between both groups as regards functional and haemogasometric parameters.

By performing linear regression analysis (Table 3) we observed that the only significant predictor of EID in stable COPD was the base-line SaO_2, by studying the sensitivity of base-line SaO_2 at predicting EID we observed a cut off value below 95% had a sensitivity of 92.9%.

Discussion

Chronic obstructive pulmonary disease is a worldwide health issue, affecting up to 15 million people in the United States in 1995, and is responsible for as many as 18.6 deaths per 100,000 persons [9,10].

Over the past 3 decades, the role of long-term oxygen therapy in the outpatient setting also has become widely applied

Table 3 Multiple linear regression analysis.

	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	53.440	23.377		2.286	0.027*
FEV_1 (%)	0.069	0.083	0.233	0.837	0.407
DLCO	−0.030	0.032	−0.128	−0.937	0.353
Baseline SaO_2	−0.620	0.219	−0.421	−2.829	0.007*
Resting $PaCO_2$	0.117	0.066	0.255	1.787	0.080
PAP	−0.074	0.084	−0.179	−0.881	0.383
mMRC DYSP	1.980	1.466	0.383	1.350	0.183

Dependent variable: SaO_2 delta.
* means significant < 0.05.

for resting hypoxemia and exercise desaturation [11,6]. In our study we aimed at studying resting parameters that may predict EID in COPD patients.

We observed that there is no significant difference between DS & NDS groups as regards age, FEV_1/FVC, TLC, and RV, and this was matching with the study of Shim et al. [12] who also observed that there was no statistical difference of age, FEV_1/FVC ratio or residual volume between the two groups.

The results of our study revealed that FEV_1 & DLCO were significantly lower in the desaturated group and this is consistent with results of Shim et al. [12] who said that lung diffusing capacity was significantly lower in the desaturated (DS) group (62 ± 18% predicted) compared with non desaturated (ND) group (84 ± 20, $P < 0.01$). Van Gestel et al. [2] found that the only independent predictor of exercise induced desaturation (EID) was FEV_1 and the optimal cutoff value of FEV_1 was at 50% of the predicted value ($P < 0.001$). They concluded that EID is highly prevalent among patients with COPD and can be predicted by FEV_1. Also Khaled et al. [1] found that the risk of oxygen desaturation during submaximal exercise was very high in patients with restriction and low DLCO (as in interstitial lung disease) and in patients with obstruction and low DLCO (as in COPD), intermediate in patients with only a low DLCO, and lowest in those with a normal DLCO.

Owens et al. [8] evaluated 48 patients with chronic obstructive pulmonary disease by means of pulmonary function and exercise testing to determine whether any tests of pulmonary function could predict the development of arterial desaturation during exercise and they supported our results where, they found that DLCO and FEV_1 were predictive of desaturation.

Our study revealed that the mMRC dyspnea score was significantly higher in the desaturated group compared to the non desaturated group, Torres et al. [13] reported that the mMRC dyspnea score negatively correlated with PaO_2 ($r = -0.59$, $P < 0.001$), and $PaCO_2$ ($r = 0.27$, $P = 0.05$) from which we can conclude that the higher the dyspnea score the higher the possibility of exercise desaturation; on the other hand a recent study [12] mentioned that six minute walking distance, and subjective dyspnea scale, did not predict exertional oxygen desaturation, that is not consistent with our results.

Our results demonstrated that resting $PaCO_2$ & PAP were significantly higher in the DS group, O'Donnell et al. [14] supported our results, where they found that during exercise, the strongest correlates of serial changes in $PaCO_2$ from rest included concurrent changes in oxygen saturation (partial $r = 0.816$, $P < 0.0005$), and end-expiratory lung volume expressed as a percentage of total lung capacity ($r = 0.562$, $P < 0.0005$), also Weitzenblum et al. [15] on studying sleep-related O_2 desaturation and daytime pulmonary homodynamic in COPD patients with mild hypoxemia observed that whereas daytime PaO_2 was similar in the desaturated and non-desaturated groups daytime $PaCO_2$ was significantly higher in the desaturated group.

Christensen et al. [16] reported that pulmonary arterial pressure during exercise was negatively correlated with arterial oxygen tension. Minai et al. [17] added that Studies have reported a rate of rise in mPAP of 0.5–1.5 mmHg/year in patients with COPD. Patients with a more significant rise in mPAP over time typically are those with rapidly worsening hypoxemia.

The current study documented that resting SaO_2 (baseline SaO_2) was significantly lower in desaturated COPD, and by performing linear regression it was the only significant predictor of exercise desaturation in COPD. Baseline SaO_2 <95% had 92.9% sensitivity as a predictor of exercise desaturation, this is consistent with Knower et al. [18] who concluded that in patients with COPD, baseline saturation of 95% or less is a good screening test for exercise desaturation especially in patients with DLCO greater than 36%.

Conclusion

Although multiple factors can predict exercise desaturation in stable COPD (including FEV_1%, DLCO, resting SaO_2, resting $PaCO_2$, mMRC dyspnea score, and pulmonary artery systolic pressure), the base line SaO_2 is the most sensitive factor.

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